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ABSTRACT

Twenty-three years after the launching of the first satellite, there is still no fully operational direct broadcasting satellite system. Since such systems were expected much earlier, many questions present themselves concerning (1) whether there is a perceived need for such a system, (2) whether the technology is available at cost effective levels, (3) whether that technology has been adequately tested, and (4) whether the system could create more problems than it would solve. An evaluation of the situation suggests that there is a need for direct broadcast satellites to serve large areas of low population density and that the technology is available at cost effective levels: experiments and studies in Canada have indicated that low power level satellites are especially cost effective. In addition, the technology is being tested and three satellite launches have been conducted: HERMES, providing service to Canada, the United States, and Australia: YURI, providing service to Japan: and ANIK-B, providing service to Canada. Other projects are currently under consideration in more than nine countries. Problems do arise from the system, since satellite coverage is very broad and the signal cannot be prevented from crossing national borders, thus causing conflicts between the provision of a totally free flow of information and the right of each nation to determine what shall be broadcast to its citizens. (HKM)

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"DIRECT BROADCASTING SATELLITES - MYTH OR REALITY"

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by

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DIRECT BROADCASTING SATELLITES - MYTH OR REALITY

1. Introduction:

It is 23 years since the first artificial satellite achieved orbit. In that time dozens of spacecraft have successfully completed very complex missions in earth orbit, as lunar probes and in planetary exploration. Progress over those 23 years has been outstanding.

It is 17 years since the first serious proposal was advanced for the use of satellites to broadcast television programs directly to home receivers. In fact 13 years ago I heard a prediction, made in all seriousness, that within three years satellite broadcast service would be available throughout a specific country. Yet despite 17 years, there is today no fully operational direct broadcasting satellite system. In that field of space technology, progress has not been outstanding.

The contrast is surprising. Surely it is simpler to broadcast a television signal from a geostationary satellite, than to recover images from a spacecraft orbiting another planet. Yet we have images from other planets and we don't have an operational direct broadcasting system. After 17 years of search we must ask if the broadcasting dream is an elusive myth or an imminent reality.

That is too complex a question to answer in one step. It requires the evaluation of four simpler questions:

- is there a perceived need for direct broadcast satellites?
- is the technology available at cost effective levels?
- has the technology been adequately tested?
- does it create more problems than it solves?

2. Perceived Need:

Direct broadcast satellites are one of three options for the distribution of television signals. The already established techniques are through-the-air broadcasting from terrestrial transmitters, and ducted transmission through cable or fiber systems. The need for satellite broadcast must be as a complement or as a replacement for the other methods.

The complementarity arises from the ability of satellites to serve areas of low population density. In terrestrial broadcast systems the capital and operating costs are concentrated in the broadcasting station. Its coverage range is limited, therefore it is a cost-effective technique only when a large population lives within that range, i.e. in urban areas. In cable systems the range is also limited, hence they too are best suited for urban areas.

A satellite broadcast system is quite different. Even with narrow beam antennae the coverage area is very large - of the order of 1,500 kms across. Within that area the signal is available to all residents, whether in urban or rural areas. Thus, satellites can complement the existing broadcast systems.

However, satellites are not a replacement for the more traditional broadcasting techniques. They are limited in channel capacity by problems of orbit and frequency congestion, therefore cannot compete with cable systems for programing choice. In addition, particularly in areas remote from the equator, some viewers could be shadowed by large buildings so that the signal from a satellite is degraded.

Thus the perceived need for satellite broadcasting systems is to serve large areas of low population density. To satisfy that need it must

be demonstrated that the technology is available, is reliable and is cost-effective.

3. Satellite Broadcasting Technology:

The key to successful broadcasting is low cost receivers. That key was not available to satellite system designers until 1971 when the Space World Administrative Radio Conference (WARC) allocated the 14/12 GHz band exclusively for satellite service. That decision freed the satellite system designer from the demands of coordination with terrestrial systems, allowed him to think of high power radiated from the satellite and thus, envisage very low cost earth terminals.

In the 1977 WARC, tentative specifications were developed for broadcast satellites in that band. The proposals envisaged the use of very small, low cost receiving stations with antennas of 1 metre diameter. To ensure that the signal was of "excellent" quality under the worst propagation conditions, the specification called for an equivalent isotropic radiated power (eirp) from the spacecraft of about 65 dBw. For comparison, fixed service satellites planned for the same band will operate in the 40-50 dB range, while satellites for domestic service in the 6/4 GHz band operate at 33-36 dBw levels.

The first satellite to test such high powers was HERMES, launched in 1975 as a joint project of USA and Canada. Its high power transponder operated at 200 watts yielding a eirp of 59.5 dBw, still 3.5 dB below the '77 WARC recommendation. HERMES operated very well for four years, demonstrating in Canada, USA and Australia that direct broadcasting was technically feasible.

Subsequently, in 1978, Japan launched their first direct broadcast satellite YURI, which operated, at least partially, until mid-1980.

However, there are drawbacks to such a high power system. The satellites with such large transponders and correspondingly large power supplies are expensive to build, costly to launch, and are less reliable than more moderate power satellites. They must use a dedicated frequency allocation since it is very difficult to coordinate broadcast and fixed service satellites in the same band with 13 dB power differentials. Thus, there are advantages to the use of lower powers in the broadcast satellites.

To explore the practicality of direct broadcasting at significantly lower power levels we, in Canada, have conducted theoretical studies, confirmed by practical tests, over the past two years.

Our interest was first sparked by tests of viewer reaction to signal quality. It was assumed at the 1977 WARC that a carrier to noise ratio of 14 dB must be guaranteed at all times to provide a satisfactory signal. We have conducted tests in both urban and rural environments which demonstrate (figure 1) that a C/N ratio of 11.5 dB is quite satisfactory for direct reception. In addition, changes in receivers since 1977 have improved their noise performance by at least 4 dB, so it is reasonable to consider now power levels which are 7-8 dB lower than those specified in 1977.

It is equally interesting that cost studies also support the use of lower power levels. While these analyses cannot be verified until full scale production of receivers reduces their cost to anticipated levels, figure 2 does give some justification for the hypothesis that lower power satellites are suitable for direct broadcasting.

The practical guidance for these studies has been provided by four transponders on the ANIK-B satellite. These channels operate at 50 dBw with coverage as shown in figure 3. They have been used for a variety of pilot

projects including both community and direct broadcast. To conduct these trials, we have had 100 earth terminals manufactured using 1.2 meter antenna within the inner coverage contour and 1.8 meters in the outer contour. While the final test results are not yet known, we can say that the quality of reception has been acceptable, and the trial has provided some confidence in the cost and performance forecasts for the earth stations.

The situation with respect to technology, therefore, is that the very high power satellites proposed at the 1977 WARC have not yet been demonstrated to have the reliability normally associated with operational systems. It has been shown, however, that acceptable quality of reception can be achieved with much lower powered satellites, while retaining the advantages of low cost, small earth stations. Both the satellites and the earth stations are available for these power levels.

However one must also ask if the technology is cost effective. Again, subject to all the caveats about extrapolation of costs to mass production, the situation for Canada is depicted in figure 4. Additionally, our studies show that there are about 4 million persons in Canada who are not adequately served by existing television broadcast. Thus, direct broadcast from moderate powered satellites is an economically attractive complement to the existing Canadian television coverage.

4. Technology Tests:

So far there have been only three tests of direct broadcasting satellites in the 12 GHz band. Two have been of high power satellites, the third a moderate power.

HERMES was launched in 1975 with a planned life of two years. It worked well until December 1979, when control was lost. During its four

year life it provided demonstrations in Canada, USA and Australia. It proved the value of the concept.

YURI was launched by Japan in 1978 with three transponders, each with a peak output power of 59 dBw. Problems have been encountered throughout the test period, so that only partial operation has been achieved. The satellite was turned off in July 1980.

ANIK-B was launched in 1978 as a fixed communications satellite for Canadian service. It contains 12 transponders in the 4 GHz band and four in the 12 GHz band. These 12 GHz channels, with an eirp of 50 dBw have been used, with improved earth terminals, for community and direct broadcasting demonstrations.

Despite the mixed success of these demonstrations, several other countries have already announced direct broadcasting plans. Without attempting to be exhaustive, Table I shows the status of some of the announced systems as of August, 1980.

Country/Agency	Title	Launch Target	Service	Status
Japan	BSE II	1984	Operational	Specification
Germany	T-V-SAT	1984	Pre-operational	Development
France	T-V-SAT	1984	Pre-operational	Development
Luxembourg	LUX-SAT	1983(?) or 1985	Operational	Management Decision re: Strategy is imminent
Scandinavia	NORDSAT	-		Discussion
Switzerland	TEL-SAT	-		Discussion
ESA	L-SAT	1984	Experimental	Planning
USA	COMSAT	1983(?)	Operational	Planning
Australia	DOMSAT	1984	Operational	Specification

TABLE I: Partial List of Broadcast Satellite Projects - August 1980.

Clearly, even though there have been only three demonstrations, the concept of direct broadcasting by satellite is attractive.

5. The Problem Areas:

Unfortunately, it is just that characteristic which gives satellites their value in broadcasting that has led to problems in deployment. Satellite coverage is very broad. No matter how skillfully the antenna designer practices his art, he cannot tailor the illuminated area to provide adequate signal to the edges of the target country with no coverage in adjacent countries. Cross-border spillover is an inevitable consequence of broadcast from satellites.

This problem has been studied by the UN Committee on the Peaceful Uses of Outer Space since 1964. The debates since then have been marked by many attempts to find a compromise between two extreme positions, one favouring a totally free flow of information, the other favouring the right of each nation to determine what shall be broadcast to its citizens. Despite fifteen years of debate, the situation after the 1979 sessions has been summarized as:

"In what has unfortunately become an annual occurrence, the 1979 sessions of the UN Committee on the Peaceful Uses of Outer Space (the Outer Space Committee) and its Legal Sub-Committee (LSC) have again come and gone without a consensus having been reached on the draft principles on Direct Broadcast Satellites (DBS). Again there was a sterile debate on the major outstanding issue, the balance that should be struck between the "free flow of information" and the right of the receiving state to "agree" before television signals can be beamed from the satellite of one state directly into individual home or small community receivers in the territory of other states (until 1977, this was referred to as the issue of "prior consent"). As each year passes without the deadlock being broken, the Outer Space Committee loses credibility as the focal point in the UN system responsible for taking an overview of all aspects of outer

space issues, including the "hardware", "software", political, legal, social and cultural aspects." (1)

Other UN Agencies have also debated the problem. As a technical issue the ITU, in Radio Regulation 428A has determined that "all technical means available shall be used to reduce .....the radiation over the territory of other countries unless an agreement has been previously reached with such countries." The Outer Space Committee has been unable to agree that this technical agreement could be used as a model for program content.

Similarly, UNESCO, in 1972 tabled its own agreement to encourage the use of satellite broadcasting for the free flow of information, the spread of education and greater cultural exchange. This agreement requires that states "reach or promote prior agreements concerning satellite broadcasting to the population of countries other than the country of origin of the transmission." Again this has not served as a model for the Outer Space Committee.

So, as of 1980, the situation is that direct broadcasting from satellites is technically feasible, is economically attractive, but is snarled in the debates of international law.

But that status is unstable. Despite the lack of agreement, several countries are already planning to have broadcasting satellites within the next few years. Even if those plans now precipitate an international agreement, it may be unenforceable since Canada's experience with ANIK-B has shown that it is already difficult to differentiate between satellites for fixed service and those for broadcasting service. That conclusion is

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(1) Dr. John H. Chapman and Gabriel I. Warren; Direct Broadcast Satellites; The ITU, UN and the Real World[1]; Annals of Air and Space Law, Centre for Research of the Institute of Air and Space Law, McGill University, Vol. IV, 1979, pp 413-432.

strengthened by the emergence of "pirate" stations in North America, low cost "do-it-yourself" TV receive-only stations which intercept signals from the 6/4 GHz fixed service satellite - anxious viewers may not wait for the blessing of international law!

So it now appears that the long gestation period is over. Direct broadcasting from satellites is an idea whose time has come. It's no longer a myth, it's an imminent reality.

Alex Curran
Assistant Deputy Minister
Space Program
Department of Communications

International Institute of Communications Conference
8-11 September, 1980

Additional Reading

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Smith, Delbert D.; YURI: The First Dedicated Broadcast Satellite in Japan; Satellite Communications, July 1978, pp 23-29;

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Chambers, J.G.; An Evolutionary Approach to the Introduction of Direct Broadcasting Satellite Service; To be published in the Proceedings of the IEEE 1980 National Telecommunications Conference;

Roscoe, O.S.; Direct Broadcast Satellite - The Canadian Experience; Satellite Communications, August 1980, pp 22-32;

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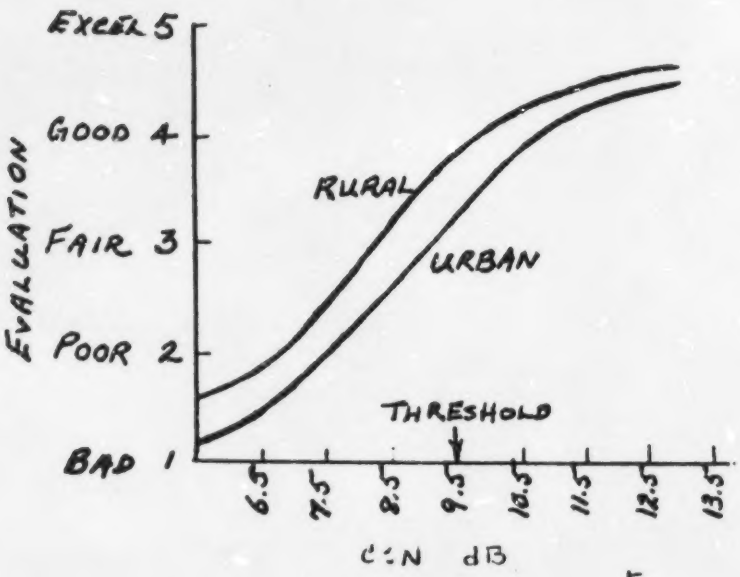
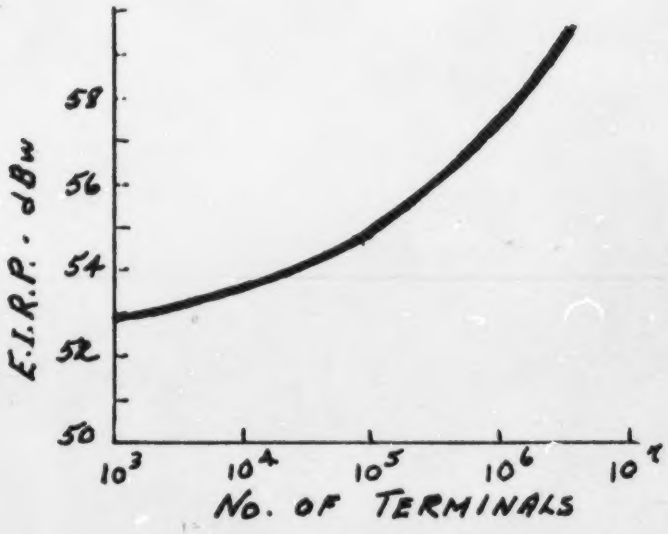


FIG. 1
MEDIAN VIEWER EVALUATION
DBS TRANSMISSION

FIG. 2
RADIATED POWER FOR MINIMUM COST DBS
12 GHz



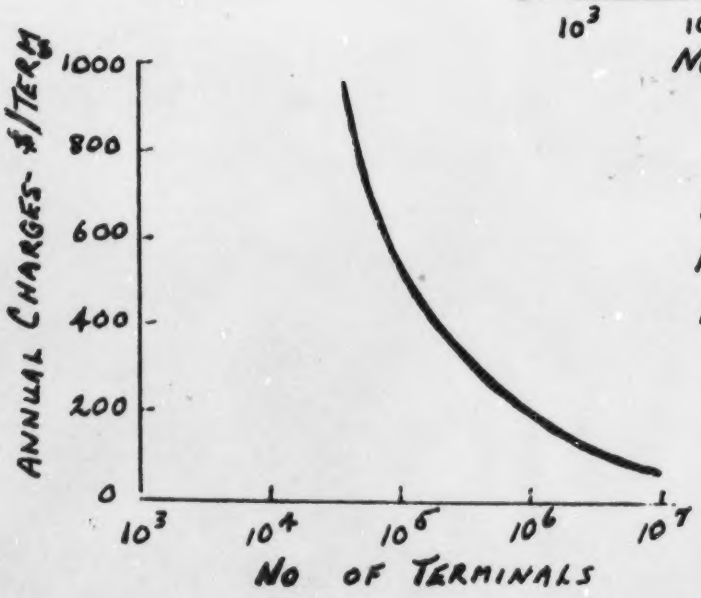
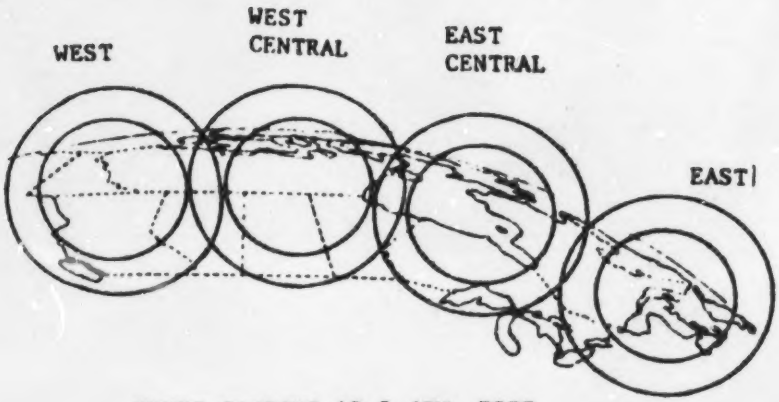


FIG. 4
REPRESENTATIVE COSTS
MODERATE POWER DBS.



INNER CONTOUR 49.5 dBW. EIRP
OUTER CONTOUR 46.5 dBW. EIRP

Fig. 3

ANIK B 12 GHz DOWNLINK
BEAM PATTERN